Remarks

In view of the above amendments and the following remarks, reconsideration of the objections and rejections, and further examination are requested.

Claims 1-16 are pending in this application. Claims 1-16 stand rejected. Claims 1, 3-5, and 7-12 are amended herein. Claims 2 and 13 are cancelled herein. No new matter has been added.

An Information Disclosure Statement is filed herewith that lists two documents for the Examiner's consideration.

The specification and abstract have been carefully reviewed and revised to make grammatical and idiomatic improvements in order to aid the Examiner in further consideration of the application. A substitute specification and abstract including the revisions have been prepared and are submitted herewith. No new matter has been added. Also submitted herewith are marked-up copies of the substitute specification and abstract indicating the changes incorporated therein.

Claims 1, 3-5, and 7-12 have been amended so as to make a number of editorial revisions thereto. These revisions have been made to place the claims in better U.S. form. None of these amendments have been made to narrow the scope of protection of the claims, or to address issues related to patentability, and therefore, these amendments should not be construed as limiting the scope of equivalents of the claims which are offered by the Doctrine of Equivalents.

The Examiner has objected to the disclosure. More specifically, the Examiner has asserted that the word "compliment" is misspelled in the disclosure and should be corrected to "complement". The substitute specification and the claims include amendments addressing the misspelling identified by the Examiner. Accordingly, the Applicants respectfully submit that the disclosure, as amended, satisfies the Examiner's concerns.

For the reasons set forth above, the Applicants respectfully request that the objection to the disclosure be withdrawn.

Claims 1-16 have been rejected under 35 U.S.C.§ 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicants regard as the invention. More specifically, the Examiner asserts that claim 1 includes

a phrase "imparted by heat treatment including carbonitriding and induction hardening" that is unclear because it is unclear what the process is. More specifically, the Examiner asserts that the phrase may be read in any one of several different ways. Moreover, the Examiner asserts that it is unclear how many processes are taking place and if they are taking place simultaneously or separately. Regarding claim 4, the Examiner asserts that the phrase "high temperature tempering" is indefinite because there is no basis for comparison of what constitutes "high temperature".

Claim 1 has been amended to recite, in part, a heat treatment comprising, in order, carbonitriding, oil quenching and induction hardening. Claim 4 has been amended to remove "high temperature". Accordingly, the Applicants respectfully submit that claims 1 and 4, as amended, satisfy 35 U.S.C. § 112, second paragraph.

For the reasons set forth above, the Applicants respectfully request that the 35 U.S.C. § 112, second paragraph, rejection be withdrawn.

Claims 1, 2, 4 and 8 have been rejected under 35 U.S.C. § 102(b) as being anticipated by Takagi et al. (U.S. Patent No. 5,560,787) (hereinafter referred to as "Takagi"). Claims 3, 7 and 9 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Takagi in view of Yoshida et al. (U.S. Patent No. 5,803,993) (hereinafter referred to as "Yoshida"). Claims 5, 6, 10, 12, 13, 15 and 16 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Takagi in view of Fredericksen et al. (U.S. Patent No. 4, 878,463) (hereinafter referred to as "Fredericksen"). Claims 11 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Takagi in view of Yoshida and further in view of Fredericksen.

Claim 1 has been amended to further distinguish the present invention, as recited therein, from the references relied upon in the above-mentioned rejections.

The above-mentioned rejections are submitted to be inapplicable to amended claim 1 for the following reasons.

With exemplary reference to the figures, claim 1 sets forth a roller bearing 1 including an inner ring 5 and an outer ring 6 made of a high carbon chrome bearing steel, a carburized steel or a carbon steel for mechanical structures, and a plurality of rolling elements 7 mounted between the inner ring 5 and the outer ring 6, wherein at least one of the inner ring 5 and the outer ring 6

is subject to a heat treatment comprising, in order, carbonitriding, oil quenching and induction hardening such that a surface layer of the at least one of the inner ring 5 and the outer ring 6 has a compressive strength of not less than 200 MPa, and a tempering hardness at 500° C of not less than Hv 550.

Thus, claim 1 requires a roller bearing including, in part, an inner ring and an outer ring made of a high carbon chrome bearing steel, a carburized steel or a carbon steel for mechanical structures, wherein at least one of the inner ring and the outer ring is subject to a heat treatment including, in order, carbonitriding, oil quenching and induction hardening such that a surface layer of the at least one of the inner ring 5 and the outer ring 6 has a compressive strength of not less than 200 MPa, and a tempering hardness at 500° C of not less than Hv 550.

In contrast, Takagi discloses a roller bearing for use in a high temperature environment such as in a jet engine. The bearing is made of a high speed steel to prevent softening of the bearing during rotation and so that the bearing can withstand tensile stresses resulting from centrifugal forces during rotation. During manufacture, at least one of an inner race, an outer race, and rolling elements is composed of a bearing material that is subjected to heat treatment including carbonitriding, followed by hardening and tempering so that the surface layer has an average residual compressive strength of not less than 225 MPa and not greater than 400 MPa over the surface to a depth of 2 millimeters. Notably, the surface hardness of Takagi should not be less than H_RC 60 at expected temperatures of between 300° C and 400° C, instead of having a tempering hardness at 500° C of not less than Hv 550, as required in claim 1.

Based on the above discussion, it is apparent that the bearing of Takagi teaches using high speed steel and a hardness not less than H_RC 60 at temperatures between 300° C and 400° C. It should be understood that the high-speed steel of Takagi is different in composition from the claimed high chrome bearing steel, carburized steel and carbon steel. Moreover, there is no disclosure or suggestion to modify the bearing of Takagi by manufacturing it from a high carbon chrome bearing steel, a carburized steel or a carbon steel for mechanical structures, wherein at least one of the inner and outer rings has a tempering hardness at 500° C of not less than Hv 550. In other words, Takagi does not disclose a roller bearing including an inner ring and outer ring made of a high carbon chrome bearing steel, a carburized steel or a carbon steel for

mechanical structures, wherein at least one of the inner ring and the outer ring is subject to a heat treatment including, in order, carbonitriding, oil quenching and induction hardening such that a surface layer of the at least one of the inner ring 5 and the outer ring 6 has a compressive strength of not less than 200 MPa, and a tempering hardness at 500° C of not less than Hv 550.

The Examiner cited the Yoshida reference for disclosing a steel with a prior austenite grain diameter within the claim range of 10 or more for the purpose of obtaining desired torsional fatigue strength and steel having a hardness of greater than 720 Hv and surface compressive stress of 850 MPa. More specifically, Yoshida discloses a method for fabricating a crude material having a regulated fine grain structure worked by hot forging, and raising the dimensional accuracy of the fabricated material by cold forging. The crystal grain size has to be controlled to eight or more in terms of JIS grain size number because the crystal grain size has to be fined to 8 or more in terms of the JIS grain size number in order to obtain the desired torsional fatigue strength period. Further, the surface hardness and the serration end has been controlled to 720 or more in terms of HV because it is necessary for achieving a torsional strength of at least 1800 MPa or more. A two stage shot pinging treatment is provided to both ends of a serration part after a high frequency hardening and tempering to increase the compression residual stress on the surface. However, it is clear that Yoshida requires controlling the crystal grain size to 8 or more in terms of JIS grain size number in order to obtain a desired torsional fatigue strength, and fails to disclose or suggest a heat treatment comprising, in order, carbonitriding, oil quenching and induction hardening such that a surface layer of at least one of an inner ring and an outer ring has a compressive strength of not less than 200 MPa, and a tempering hardness at 500° C of not less than Hv 550, as recited in claim 1. Therefore, Yoshida fails to address the deficiencies of Takagi.

The Fredericksen reference was cited by the Examiner for disclosing a needle roller bearing arranged in a full complement arrangement for the purpose of having a bearing on which the loading is distributed, reducing valve train friction, increasing edge of performance, liability and life expectancy of a rocker arm, lower cost and to allow easy installation. However, Fredericksen also fails to address the deficiencies of Takagi.

For at least the reasons set forth above, it is believed clear that claim 1, and claims 3-12 and 14-16 depending therefrom, are not anticipated by Takagi. Further, it is submitted that there is no teaching or suggestion in the prior art of record that would have caused an ordinary artisan to modify Takagi, in view of Yoshida and Fredericksen, in such a manner as to result in, or otherwise render obvious, the invention of claim 1, and claims 3-12 and 14-16. Therefore, it is submitted that claims 1, 3-12 and 14-16 are clearly allowable over the prior art of record.

In view of the foregoing amendments and remarks, all the claims now active in this application are believed to be in condition for allowance. Reconsideration and favorable action is respectfully solicited.

Should the Examiner believe there are any remaining issues that must be resolved before this application can be passed to issue, it is respectfully requested that the Examiner contact the undersigned by telephone in order to resolve such issues.

Respectfully submitted,

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Version with Markings to Show Changes Made

ROLLING BEARINGS

BACKGROUND OF THE INVENTION

【0001】 This invention relates to rolling bearings used for applications where lubricating conditions are severe or bending stress acts, such as bearings for rocker arms of automobiles.

【0002】 In recent years, in machines such as automobiles, for lower fuel consumption or freedom from maintenance, bearings are often operated under harsher lubricating conditions than before, e.g. with lubricating oil having low viscosity or used for a long period of time without renewing lubricating oil. In bearings used for applications where lubricating conditions are severe, ~~no~~ a suitable oil film ~~is sometimes formed~~ sometimes does not form between bearing rings and rolling elements, so that due to surface heat buildup or metallic contact, required life is not met.

【0003】 In particular, in full ~~compliment~~ complement roller bearings, since the amount of lubricating oil supplied into between the bearing rings and the rollers tends to be insufficient, peeling from the surface of a bearing ring tends to occur. For example, in bearings for automotive rocker arms as shown in Fig.

1, which shows an embodiment of the present invention, or in needle bearings, the working life often shortens markedly because peeling develops in the inner ring (or shaft integrally formed with the inner ring).

【0004】 On the other hand, because~~ in the future~~, rolling bearings are anticipated to be used at higher loads as driving performance of machinery improves, it is expected that~~ the problem of~~ problems will develop regarding cracking of bearings~~ will become manifest~~. In particular,~~ since~~ because bearings that receive loads, not enclosed in housings, such as bearings for rocker arms, or bearings enclosed in a thin housing, are exposed to bending stress repeatedly during use, the possibility is high that cracks due to fatigue may pose a problem.

【0005】 To solve problems that arise due to increasingly harsher use conditions of rolling bearings as described above, if attempts are made to cope with such problems by changing the bearing material, the material cost would increase markedly. Thus, measures that will incur little cost increase are required by improving heat treatment procedures.

【0006】 ~~As one~~One known measure from the heat treatment aspect~~,~~ is carbonitriding treatment~~ is known~~. Carbonitriding is a technique in which nitrogen and carbon are infiltrated by diffusion through the

surface of a steel material. It imparts a ~~to impart the~~ resistance to material quality change (resistance to micro-structural change and hardness softening) to the surface layer, thereby prolonging the life of the material. Its application has expanded to inner and outer rings of bearings made of bearing steel, carburized steel and carbon steel for machine ~~structure~~ structures, which are known as ordinary materials for bearing.

【0007】 But since carbonitriding is a technique of diffusing through the material surface, a long time is taken to obtain a required carbo-nitrided depth. Thus, carbo-nitrided materials still have problems that the structure of the surface layer tends to be rough, or the crystal grains of the entire material tend to be large, thus lowering the fatigue strength.

【0008】 Further, regarding bearings for rocker arms, JP patent publication 2002-194438 discloses a method of improving the wear resistance by changing carbon concentration distributions on the outer peripheral surface and the rolling surfaces to prevent wear of the outer ring due to contact with the mating cam~~, or~~. It also discloses a method of controlling the carbon concentration and hardness of the surface layer of a shaft formed integral with the inner ring (shaft subjected to induction hardening after carburizing or

carbonitriding) and the hardness of its interior. But there have been no ~~technique~~ techniques which ~~has paid attention to~~ have addressed the rolling life or resistance to cracking.

【0009】 An object of this invention is to provide inexpensive rolling bearings which can be used stably for a long time even for applications where the lubricating conditions are severe or ones where bending stresses act.

SUMMARY OF THE INVENTION

【0010】 According to this invention, there is provided a rolling bearing comprising an inner ring and an outer ring made of a bearing steel, a carburized steel or a carbon steel for mechanical structures, and a plurality of rolling elements mounted between the inner ring and the outer ring~~, wherein to the surface layer of at least one of the inner ring and the outer ring, a~~. A compressive stress of not less than 200 MPa is imparted to the surface layer of at least one of the inner ring and the outer ring by heat treatment including carbonitriding and induction hardening.

【0011】 That is, by subjecting at least the inner ring or the outer ring to induction hardening after

carbonitriding, and imparting resistance to material quality change and a high compressive stress of not less than 200 MPa to the surface, it is possible to improve resistance to damage to the surface while keeping the material cost unchanged compared to the prior art bearing~~, thereby simultaneously achieving~~. Thus, extended rolling contact fatigue life and improved fatigue strength are achieved simultaneously.

【0012】 ~~At this time, the~~The bearing ring to be subjected to the heat treatment ~~has~~ preferably has a tempering hardness at 500 ℃ of not less than Hv 550 in the surface layer thereof from the viewpoint of the rolling fatigue life, and has a prior austenite grain diameter of not less than Gc 10 in the surface layer in view of the fatigue strength.

【0013】 Further, if high-temperature tempering is carried out between carbonitriding and induction hardening, the entire bearing rings will have low hardness when tempered, so that it is possible to further increase the compressive stress in the surface layer which is imparted by the subsequent induction hardening. Thus, it is possible to further improve the rolling contact fatigue life and fatigue strength.

【0014】 This invention can be effectively applied to rolling bearings in which ~~said~~ the rolling elements are rollers that are arranged in a full ~~compliment~~

complement arrangement.

【0015】 ~~The effect of application of this~~This invention~~ is large for bearings~~ has a substantial effect for bearing applications for a rocker arm of an automobile, which are used under severe lubricating conditions and in which bending stresses act repeatedly during use.

BRIEF DESCRIPTION OF THE DRAWINGS

【0016】 Other features and objects of the present invention will become apparent from the following description made with reference to the accompanying drawings, in which:

Fig. 1 is a front sectional view showing how the rolling bearing of an embodiment is mounted in a rocker arm.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

【0017】 With reference to Figs. 1, the embodiment of this invention will be described. Fig. 1 shows the rolling bearing 1 of the embodiment mounted in a rocker arm 4 disposed between an engine valve 2 of an automobile and a cam 3 for opening and closing the valve 2. The rolling bearing 1 comprises an inner ring

5 fitted on a fixed shaft 4a of the rocker arm 4, an outer ring 6 facing the cam 3, and a plurality of rollers 7 arranged between the bearing rings 5 and 6 in a full state. ~~On the other hand, the~~The rocker arm 4 has its central portion mounted on a pivotable rocker shaft 8, and has one end thereof coupled to the engine valve 2 so as to be biased downwardly in the figure by a valve spring 9, thereby pressing the outer periphery of the outer ring 6 of the bearing 1, which is mounted at the other end, against the cam 3. Thus, as the cam 3 rotates about its axis together with its camshaft 10, the rocker arm 4 will pivot through the bearing 1, so that the valve 2 moves up and down~~, i.e.~~. That is, valve 2 closes and opens.

【0018】 The inner ring 5, outer ring 6 and rollers 7 of the rolling bearing 1 are all made of high-carbon chrome bearing steel. During heat treatment, the rollers 7 are subjected to ordinary carbonitriding only, while the inner and outer rings 5 and 6 are subjected to carbonitriding, tempering at high temperature, and then induction hardening. By this heat treatment, a compressive stress not less than 200 MPa is imparted to the surface layers of the bearing rings 5 and 6, and the tempering hardness of the surface layer at 500 ℃ will be not less than Hv 550. As a result, the rolling contact fatigue life and the

tension-compression fatigue strength ~~will~~ markedly improve. By controlling the prior austenite grain diameter in the surface layer as fine, as not less than Gc 10, by properly setting the temperature during induction hardening, the outer ring 6 has higher tension-compression fatigue strength than the inner ring 5.

【0019】 Thus, in spite of the fact that this bearing 1 is a full ~~compliment~~complement type bearing ~~and~~, is used under ~~easy-to-worsen~~ lubricating conditions that can easily deteriorate and is exposed to bending stress and contact stress repeatedly, no premature surface peeling or cracks will develop in the bearing rings 5 and 6. Thus, the bearing 1 can be stably used for a long period~~. Thus~~, and it can ~~cope with~~ withstand increased harshness in lubricating and loading conditions ~~and~~ to improve the performance of automobiles.

【0020】 In the above embodiment, for both the inner and outer rings, a compressive stress not less than 200 MPa is imparted to their surface layers by subjecting both of them to heat treatment in which high-temperature tempering and induction heating are carried out after carbonitriding. But only one of them may be subjected to such heat treatment. According to applications and use conditions of the bearing, high-

temperature tempering among three heat treatment steps may be omitted.

【0021】 The material of the bearing rings~~, which are subjected to carbonitriding and induction heating, are~~ is not limited to bearing steel, but carburized steel and carbon steel for mechanical structures may also be used.

【0022】 Next, experiments conducted to confirm the performance of the bearing according to the present invention will be described.

(1) Rolling contact fatigue life comparison experiment

【0023】 In this experiment, the rolling fatigue life for full ~~compliment~~complement needle roller bearings in which the inner ring is integral with the shaft,~~-their rolling fatigue life~~ was examined. For the experiment, seven bearings having inner rings~~ which are~~, different in material and heat treatment, were prepared including comparative examples. Each bearing had an inner ring (shaft) of 14.64 mm outer diameter x 17.3 mm wide, an outer ring of 18.64 mm inner diameter x 24 mm outer diameter x 6.9 mm wide, and 26 rollers of 2 mm outer diameter x 6.8 mm long. The materials and heat treatments of the inner rings (shafts) are shown in Table 1 together with the results of the experiment. The outer rings and rollers were made of high-carbon chrome bearing steel and were subjected to

normal carbonitriding.

【0024】 Among the heat treatments for the inner rings (shafts) shown in Table 1, the carbonitriding for bearing steels of ~~Examples~~ examples (No. 1, No. 3) was carried out in an atmosphere having ~~the~~ a carbon potential of 1.1-1.2% and ~~the~~ an ammonia concentration of 5%[[,]] at a temperature of 850 ℃ for 90 minutes to form a carbonitrided layer having a depth of about 0.3 mm, and then oil quenching was carried out. The carbon concentration in the surface layer after carbonitriding was 1.05-1.1% and the nitrogen concentration was about 0.25%.

【0025】 On the other hand, for carbonitriding of carburized steel (No. 2, No. 4), in the heating time of 400 minutes at 920 ℃, for the first 250 minutes, only carburization was carried out in an atmosphere having the carbon potential of 1.0%, and for the last 150 minutes, carbonitriding was carried out in an atmosphere having the carbon potential of 0.8% and the ammonia concentration of 7% ~~to form~~. Thus forming a carburized and hardened layer having a depth of about 1.5 mm and a carbonitrided layer having a depth of about 0.3 mm, and then oil quenching was carried out. After the treatment, the carbon concentration in the surface layer was about 1.0% and the nitrogen concentration was about 0.35%.

【0026】 In the induction hardening (No. 1-4) after the carbonitriding for each ~~Example~~ example, a hardened layer having a depth of about 1 mm was formed. When high-temperature tempering was carried out between carbonitriding and induction hardening (No. 3 and No. 4), the tempering temperature was 600 ℃.

【0027】 In contrast, among ~~Comparative Examples~~ comparative examples, for standard heat treatment for bearing steel (No. 5), after heating at 850 ℃ for 45 minutes in an atmosphere having the carbon potential of 0.9%, oil quenching was carried out. Conditions of carbonitriding for bearing steel (No. 6) were the same as those of ~~Examples~~ examples (No. 2 and No. 4). In the standard carburizing for carburized steel (No. 7), in the heating time of 400 minutes at 920 ℃, for the first 250 minutes, carburizing in an atmosphere having the carbon potential of 1.0%, and for the last 150 minutes, diffusing in an atmosphere having the carbon potential of 0.8% was carried out, and then oil quenching was carried out.

【0028】 These bearings were set in an outer ring rotating type life tester and the time ~~taken~~ elapsed until peeling occurred in the surface layer of each inner ring (shaft) was measured under the following conditions:

(Test conditions)

Load: 2.58 kN (30% of basic dynamic rated load)

Outer ring rotating speed: 7000 rpm

Lubricating oil: engine oil (10W-30)

Lubricating oil temperature: 100 ℃

【0029】 The time taken until surface layer peeling occurred in the inner ring (shaft) of each bearing was converted to a ratio with reference to the standard heat-treated article of bearing steel (No. 5), and was shown in Table 1 as the rolling fatigue life ratio.

【0030】 As is apparent from Table 1, in each ~~Example~~ example, in the surface layer of the inner ring (shaft), a compressive stress of not less than 200 MPa and a 500 ℃ tempering hardness of not less than Hv 550 were ensured. Thus, the rolling contact fatigue life was 3.5 times that of the standard article (No. 5) or over. Further, among the ~~Examples~~ examples, those in which high-temperature tempering was carried out between carbonitriding and induction hardening (No. 3 and No. 4) were high in compressive stress and long in life compared with those ~~in which the kind of steel was~~ having the same steel but no high-temperature tempering ~~was carried out~~ (No. 1 and No. 2).

(2) Tension-compression fatigue life comparison experiment

【0031】 In this experiment, a total of seven kinds (four each) of ring test specimens that differed in

material and heat treatment were prepared. Dimensions of each test piece were 45 mm inner diameter x 60 mm outer diameter x 15 mm wide. The material and heat treatment are shown in Table 2 together with the results of the experiment. The contents of the heat treatment for each of the ~~Examples~~ examples and ~~Comparative Examples~~ comparative examples are the same as those described about Table 1.

【0032】 Each of these test pieces was set on a ring rotating type fatigue life tester, and loads were applied repeatedly while rotating under the following test conditions~~, and the~~. The number of loadings was repeated until cracks developed and were measured.

(Test conditions)

Load: 9.8 kN

Load speed: 8000 cpm

Lubricating oil: turbine oil (VG68)

【0033】 The number of loadings repeated until each test piece cracked was converted to a ratio with reference to the standard heat-treated article of bearing steel (No. 5), and shown in Table 2 as a tension-compression fatigue life ratio. The numerical values in Table 2 are average values for four test pieces of each kind.

【0034】 As is apparent from Table 2, each ~~Example~~ example showed the compressive stress in the surface

layer of not less than 200 MPa, ~~and~~ the 500 ℃ tempering hardness of not less than Hv 550, and the prior austenite grain diameter of not less than Gc 10. This shows that the tension-compression fatigue life markedly improved compared to the standard article (No. 5).

【0035】 As described above, according to this invention, by subjecting at least one of the inner ring and the outer ring of the rolling bearing to induction hardening after carbonitriding, resistance to material quality change and a high compressive stress of not less than 200 MPa are imparted. Thus, it is possible to markedly improve the rolling fatigue life and the crack fatigue strength with no increase in the cost of the bearing material.

【0036】 Thus, the rolling bearing to which this invention is applied can be used stably for a long time even in applications where lubricating conditions are severe or in applications where bending stresses act. Thus it is possible to cope with severer lubricating and load conditions expected in the future.

TABLE 1

	No.	Material	Heat treatment	Hardness (Hv)	Compressive stress (Mpa)	Tempering hardness at 500°C (Hv)	Rolling contact fatigue life ratio
Ex.	1	Bearing steel	Carbonitriding + induction hardening	770	230	600	3.5
	2	Carburized steel	Carbonitriding + induction hardening	750	450	620	3.8
	3	Bearing steel	Carbonitriding + high temperature tempering + induction hardening	850	370	610	4.6
	4	Carburized steel	Carbonitriding + high temperature tempering + induction hardening	830	520	630	5.0
Comp. Ex.	5	Bearing steel	Standard heat treatment	740	0	470	1.0
	6	Bearing steel	Carbonitriding	780	120	580	1.9
	7	Carburized steel	Standard carburizing	720	290	480	1.3

TABLE 2

	No.	Material	Heat treatment	Hardness at surface layer (Hv)	Compressive stress (Mpa)	Tempering hardness at 500°C (Hv)	Prior austenite grain size (Gc)	Tension-compression fatigue life ratio
Ex.	1	Bearing steel	Carbonitriding + induction hardening	780	200	610	11	3.7
	2	Carburized steel	Carbonitriding + induction hardening	770	420	600	10	4.9
	3	Bearing steel	Carbonitriding + high temperature tempering + induction hardening	840	350	580	11	4.0
	4	Carburized steel	Carbonitriding + high temperature tempering + induction hardening	820	590	610	10	5.3
Comp. Ex.	5	Bearing steel	Standard heat treatment	740	50	470	9 ~ 10	1.0
	6	Bearing steel	Carbonitriding	760	120	590	8 ~ 9	2.2
	7	Carburized steel	Standard carburizing	720	340	470	4 ~ 8	2.8

ABSTRACT OF THE DISCLOSURE

An inexpensive rolling bearing is proposed which can be used stably for a long time ~~even for applications~~ where the lubricating conditions are severe or bending stresses act. Inner and outer rings of rolling bearings mounted in a rocker arm of an automobile are made of high-carbon chrome bearing steel. They are subjected to heat treatment in which after carbonitriding, high-temperature tempering is carried out. Then they are induction hardened to impart resistance to material quality change and a compressive stress of not less than 200 MPa to the surface layer, thereby markedly improving the rolling contact fatigue life and the tension-compression fatigue strength while keeping the material cost as before. Thus, this bearing can be used stably for a long time even though it is a full ~~compliment~~ complement type bearing, lubricating conditions tend to worsen and the outer ring is repeatedly subjected to bending stress from the cam.